植物油混方之研發與應用

余志儒[1*]、董耀仁[2]、許北辰[2]、楊婉秀[2]

[1]農委會農業試驗所應用動物組副研究員。台灣　台中市　霧峰區。
[2]農委會農業試驗所應用動物組助理研究員。台灣　台中市　霧峰區。

摘要

初步篩選 23 種植物種籽油、11 種植物精油對棉蚜 (*Aphis gossypii* Glover)、神澤氏葉蟎 (*Tetranychus kanzawai* Kishida)、二點葉蟎 (*T. urticae* Koch) 的防除效果。後續進一步嘗試比較飽和脂肪酸含量差異較大的三種植物油，椰子油、棕櫚油與菜籽油(分別含 94.1、51.9 與 5.1%)對二點葉蟎的效果。結果顯示三種油的 LC_{50} 在處理後 72 小時分別為 2.23、2.59 及 3.66 mL/L，LC_{90} 分別為 10.62、7.53 及 17.82 mL/L，由此推測致死效果可能與飽和脂肪酸的含量有關。椰子油與棕櫚油具發展潛力。另比較 4 個不同品牌的大豆油對棉蚜(*Aphis gossypii* Glover)的致死效果，包括市售較大品牌的 3 種 (大統企業股份有限公司、台灣糖業公司、泰山企業股份有限公司)與 Sigma-Aldrich Co. 之 R&D 級。當介面活性劑以 0.25：1 (V/V) 與各品牌油混合，殺蚜效果佳，且四者間差異不顯著。顯示大豆油有開發為防治棉蚜製劑的潛力，且介面活性劑與椰子油、棕櫚油及大豆油混合的比例，0.25：1 (V/V) 有參考價值。由上述結果，製備了植物油混方。植物油混方可應用於蟲害管理系統中的預防與治療。預防方面，於作物定植前，植物油混方可行浸苗處理，定植後則是每周噴施，藉其精油組成發揮忌避效果。依據田間監測結果，發現害蟲族群已達防治門檻時，即應進入治療階段，加強植物油混方的施用劑量、頻度等。防治策略的擬定，必須參酌製劑的特性與侷限性，了解防除對象的生態、習性等，如植物油混方的防治能力未逮時，即應廣納其他有效資材，以彌補單兵作戰可能的不足。

關鍵詞：植物油混方、浸苗處理、蟲害管理策略。

前言

投入開發植物油作為蟲害防治資材的初衷，本是為了配合生物防治，希望能找出可與生物天敵相容的友善資材，落實到以生物防治為基礎的蟲害整合管理(IPM，Integrated pests management)。

利用生物天敵雖是狹義的生物防治，但生物天敵也是生態的一份子，意義上除了蟲害防治也期望兼顧到生態保護。天敵的應用方式，包括人為釋放與保育，後者應用於農作物生產操作，更可以和綠色保育 (農委會林務局與慈心基金會合作推動綠色保育計畫，http://toaf.org.tw/conservation) 等生態議題並行不悖，可說是生物防治的理想境界。但無論何種應用方式，在天敵發揮防治效果之前，都極可能遇上因蟲

*論文聯繫人
e-mail: zyu@tari.gov.tw

害造成的經濟損失。此時就有賴其他與生物天敵相容的防治資材與技術來消弭損失，例如田間管理、友善植保資材及其應用技術等的運用 (農業病蟲害智能管理決策系統，http://azai.tari.gov.tw/)，進行害物整合管理，同時有益於農產品、人體以及環境的安全。

天然除蟲物質中的油類，如礦物油、植物油及動物油等早期就被用為農作物上的除蟲材料 (Miller 1983; Beattie 2002)。其中可食用的植物油(edible plant oil)及植物精油(essential oil)，通常被認為對人體、環境的影響相對較為友善 (Adhvaryu *et al.* 2004；Moawad *et al.* 2015)。尤其對蔬果上常見的小體形害蟲，如蚜蟲 (Mishra *et al.* 2006; Kassimi *et al.* 2012; Attia *et al.* 2016)、粉蝨 (Butler *et al.* 1988; Puri *et al.* 1991; Fenigstein *et al.* 2001; Schuster *et al.* 2009)、薊馬 (Butler & Jr. Henneberry 1990; Picard *et al.* 2012)、害蟎 (Miresmailli & Isman 2006; Esmaeily *et al.* 2017)等，都有卓著的效果。植物精油方面， Aslan *et al.* (2004) 比較三種唇形花科植物夏日風輪菜 (*Satureja hortensis* L.)、羅勒 (*Ocimum basilicum* L.)及百里香 (*Thymus vulgaris* L.)的精油揮發物質對二點葉蟎 (*Tetranychus urticae* Koch)的致死效果，其中二點葉蟎暴露於夏日風輪菜0.782、1.563及3.125 μL/L濃度的空氣中分別可殺死66.6、87.6及96.6%。Choi *et al.* (2004) 試得檸檬桉油僅需 9.3×10^{-3} μL/mL，可使二點葉蟎的死亡率達99%。因此，本所研究團隊將食用植物油與植物精油列為重要的友善植保資材研發對象。

若將植保資材比喻為武器，則需要落實於 IPM 體系的應用技術就有如武術。唯有武術的緊密搭配，武器才得以發揮應有的效果，資材及其應用技術兩者不可偏廢。由於友善資材通常不及化學合成農藥的速效或者長效，應用時需要細膩靈活的應用技術與策略，切勿單純地取代化學合成農藥，應就資材的性質與除蟲機制，以及蟲害的生態、習性，研擬應用技巧與策略。基於此，本文將植物油混方的研發及其應用策略做一簡述。

植物油混方之研發

初步篩選，自2005至2007年測試23種植物油，其中 12 種將種子以榨油機(家用型，尚磔工業有限公司)冷壓榨取後過濾備試，分別為南瓜 (*Cucurbita tinctorius* L.)、向日葵 (*Helianthus annuus* L.)、辣木 (*Moringa oleifera* Lamk.)、欖仁樹 (*Terminalia catappa* L.)、紅花 (*Carthamus tinctorius* L.)、腰果 (*Anacardium ocidentale* L.)、編號 0940416、油菜 (*Brassica campestris* L.)、乳薊 (*Silybum marianum* (Linne) Gaertner)、油桐 (*Aleurites fordii* Hemsl.))、茶樹 (*Thea sinensis* Linn.)、胡麻 (*Sesamum indicum* Linn.) 及油菊 (*Chrysanthemum* sp.)；另 11 種購自市售油商品，分別為花生、大豆、橄欖油、蓖麻、乳油木果、棉子、亞麻仁、苦茶、棕櫚、椰子、芥菜。

2005 年測試 10 種植物油，南瓜、向日葵、辣木、欖仁樹、紅花、腰果及編號 0940416、花生、大豆油、橄欖油等。經乳化後再用水稀釋 500 倍對棉蚜 (*Aphis gossypii* Glover) 、神澤氏葉蟎 (*Tetranychus kanzawai* Kishida) 及二點葉蟎之防治率，結果顯示僅 0940416 效果較佳，處理後經 1、3 及 7 日防治率分別達 87.3–98.4 %、99.3–100%及 100% (圖 1)；但 0940416 對 3 種生物天敵致死率亦高，水稀釋 1000 倍處理對小十三星瓢蟲 (*Harmonia dimidiata* (Fabricius)) 初齡幼蟲與成蟲分別為 36.7 與 3.3%，對智利捕植蟎 (*Phytoseiulus persimilis* Athias-Henriot) 初齡若蟎與基徵草蛉 (*Mallada basalis* (Walker)) 之初齡幼蟲則分別達 100.0%與 70.0% (未發表資料)，故不錄用。2006 年測 7 種，油菜、乳薊、芥菜、油桐、茶樹、苦茶、胡麻，效果皆差。2007 年測試 6 種植物油，油菊、蓖麻、乳油木果、棉子油、亞麻仁油、棕櫚油，與 Tween 80 以 9：

1 (V/V) 混合後，再以水稀釋 200 倍受測。對棉蚜 6 種油效果皆差，但其中蓖麻油、油菊油對神澤氏葉蟎的防治率較高，分別為 87.9、95.7%，對二點葉蟎則以棉子油較高，達 100% (表 1)。

為了商品化製劑，依初步結果行進一步之測試。以下以二點葉蟎與棉蚜為防除對象略述之。

飽和脂肪酸含量較高的植物油可能對昆蟲的抑制效果較好 (Hall & Harman 1991)，因此余與陳(2009)嘗試比較飽和脂肪酸含量差異較大的三種植物油，椰子油、棕櫚油及菜籽油，分別含 94.1% (Mohamed *et al.* 2002)、51.9% (Ravasio *et al.* 2002; Aguila *et al.* 2005) 及 5.1% (Rashid *et al.* 2008)，對二點葉蟎的效果。介面活性劑取用食品級 Span 80 與 Tween 80 (日本 Wako Pure Chemical Industries LTD.)，並依 Griffin (1949) 方法調製與供試植物油接近的介面活性劑HLB值進行植物油乳化，此三種油的 HLB 值分別為 5.3 (Acharya *et al.* 2002)、10.8 (Ahmad *et al.* 1996) 及 6.7 (Szelag & Zwierzykowski 1999)。油與介面活性劑以 1 : 1 (V/V) 混合，在室內 25°C ± 1°C 下進行測試。結果顯示，椰子油、棕櫚油及介面活性劑皆有殺蟎能力，菜籽油除外 (表 2)，此三種植物油的 LC_{50} 在處理後 72 小時分別為 2.23、2.59 及 3.66 ml/l，LC_{90} 分別為 10.62、7.53 及 17.82 ml/l (表 3)，由此可推測致死效果可能與飽和脂肪酸的含量有關。介面活性劑的殺蟎效果與其 HLB 值的大小似乎無關，除 10 mL/L 濃度在處理後 24 小時與 20 ml/l 濃度在處理後 72 小時之外，餘皆無顯著差異 (表 4)。與植物油的混合時，介面活性劑的比例雖愈高愈好。但由油脂 LC_{50} 濃度處理後 72 小時的結果，三種油的介面活性劑分別可以降為油的 0.5、1 及 0.125 倍 (表 5)。椰子油與棕櫚油具發展潛力。

食用油中，大豆油是常見的大宗油品，成本可能較低且易取得。余 (2009) 曾比較市售較大品牌的 3 種 (大統企業股份有限公司、台灣糖業公司、泰山企業股份有限公司)大豆油與 Sigma-Aldrich Co.之 R&D 級的大豆油對棉蚜的致死試驗，結果顯示，Sigma-Aldrich Co. 油與介面活性劑 [同余與陳 2009，但大豆油之 HLB 值採用 8 (Chang 2007; Yaghmura *et al.* 1999)] 以 1:1 混合後的效果皆佳 (表 6)，LC_{50} 與 LC_{90} 分別為 1.09–1.28 mL/L 與 3.96–5.78 mL/L (表 7)。介面活性劑亦具殺蚜效果 (表 8)，而以 0.25:1 的比例與大豆油混合，其效果與 2:1 者差異不顯著 (表 9)。以 0.25:1 與各品牌油混合，殺蚜效果四者間差異不顯著 (表 10)。由此得知大豆油有開發為棉蚜防治製劑的潛力，以及與介面活性劑的較佳比例。

另外，期望未來製劑也具有忌避效果，於是測試了植物精油。計 11 種，分別為丁香(*Eugenia caryophylla*)、肉桂 (*Cinnamomum cassia*)、茴香(*Foeniculum vulgre*)、艾葉 (*Artemisiae argyi* Levl. et Vant)、香茅 (*Cymbopogon citratus* (DC. ex Nees))、薄荷 (*Mentha piperita* L.)、樟樹(*Cinnamomum camphora* Nees et Eberm) 及 4 種尤加利 [(*Eucalyptus citriodora* (Hook)、*E. radiata* (Sieber)、*E. dives* Schauer、*E. globulus* Labill.)]，皆購自英國 FPI Sales Ltd.。

前 4 種精油對棉蚜、神澤氏葉蟎及二點葉蟎的防除效果普遍不佳 (表 11)，且會造成藥害。僅肉桂與茴香在二點葉蟎防治上可能有應用價值，其施用後 3 日之防治率分別有 75.9%與 63.8%。而香茅、薄荷、樟樹及 *E. citriodora* 尤加利等 4 種精油，對此 3 種害蟲則同時皆具有驅除與致死效果，但以對棉蚜的效果較高，1 mL/L 濃度於處理後 7 日的驅除率分別達 93.7、85.6、77.8 及 98.1% (圖 2)；致死率於處理後 1 日即得理想效果，分別為 70.2、88.5、94.7 及 81.2%；其中又以尤加利精油 0.5 mL/L 濃度之致死率在 82.1–83.3%之間 (圖 3)，可能最具潛力。

桉葉素 (1,8-cineole)是尤加利精油中重要之有效防除蟲、蟎成分 (Hori & Komatsu. 1997; Obeng-Ofori *et al.* 1997; Miresmailli *et al.* 2006; Mareggiani *et al.* 2008; George *et al.* 2009)。但不同種的尤加利精油其桉葉素的含量比例差異懸殊 (Dellacassa *et al.* 1990; Assareh *et al.* 2007; Bhatti *et al.* 2007; Sefidkon *et al.* 2007; George *et al.* 2009)，效果也可能有異。故選取 4 種不同桉葉素含量的尤加利精油 (表 12)，測試其對前述 3 種害蟲的效果。結果除蟲效果皆低，且大致上相互之間差異不顯著，以組成份種類多者 (*E. dives*) 效果較好。*E. globulus* 與 *E. citriodora* 精油皆含有 8 種組成份(雖種類不盡相同)，但以桉葉素含量高者 (*E. globulus*) 效果較佳 (表 13)。因此，除了桉葉素確有除蟲效力之外，組成份的協力效果也可能存在。

結合上述結果，將數種食用植物油、精油及食品級介面活性劑，以適當比例調製成植物油混方 (Plant Oils Mixture)。經測試，200 倍水稀釋液對基徵草蛉等天敵無致死反應，可與生物天敵的使用相容。於 2011、2012 年分別技術授權予三家業者。

植物油混方之應用

友善耕作中遇到植保問題，通常指望能有直接取代化學合成農藥的友善植保資材。但後者一般都不及前者的的速效或長效，若只是單純直接地取代，後續的風險會很大。因此使用友善植保資材時需要有細膩靈活的應用技術與策略，才能將其真正的效果完全發揮出來。植物油混方可應用於蟲害管理系統中的預防與治療。預防方面，於作物定植前，植物油混方可行浸苗處理，定植後則是每周噴施，藉其精油組成發揮忌避效果。

預防策略之浸苗處理

自行育苗或購自專業育苗場的苗，植體上都可能有未被發現或清除的害蟲棲息，是五個害蟲主要侵入途徑之一 (余與許 2017)。為避免此類種苗將害蟲攜帶入本田，必須進行浸苗處理。浸苗處理是一種健康種苗的作為，也是有效且不可或缺的預防措施，藉此可以去除種苗植體上大部份的小體形害蟲。參酌余與許 (2016) 棕櫚油浸漬神澤氏葉蟎，對該蟎卵至成蟲各齡期皆有 100%致死效果，進而設計植物油混方的浸苗技巧如下。確實執行，可清除苗株上小體形的害蟲，如棉蚜、銀葉粉蝨 (*Bemisia argentifolii* Bellows & Perring)、二點葉蟎及神澤氏葉蟎等 (余與許 2019，表二)。

浸苗處理方法及其注意事項：

1. **浸漬濃度**：植物油混方約 200-300 倍水稀釋液。
2. **浸漬時間**：整株苗，可連同育苗盤、介質完全浸入。浸漬 1 秒即有效果，延長浸漬時間有藥害風險。不同種作物、同種不同品種 (系) 間耐受度不同，例如小黃瓜翠姑品種浸 1 秒即有輕微的藥害，雖對往後發育與產值未造成影響，也不能輕忽，草莓豐香品種則可耐受 5 秒、木瓜台農 2 號 10 秒均無藥害反應。故在大量浸苗處理前，應先行藥耐受測試。
3. **藥害測試**：先取少量苗，以 100–200 倍植物油混方水稀釋液，浸漬約 1–2 秒鐘，移出後靜置 48 小時以上，觀察確認無藥害反應，才可大量處理。
4. **其他**：(1) 為避免浸漬時苗植體飄浮與育苗盤分離，可將育苗盤略為彎折再行浸漬。(2) 浸苗處理應在栽培園區外進行，因種苗可能有夾帶飛行力或跳躍力強的蟲體，浸漬時的驚擾可能會使部份蟲體逃離，反而促其散佈於園區。(3) 處理後須盡快移入園區內，因為對於浸漬後才來棲息於苗體上的蟲，可能無懼於植物油混方的忌避，且無治療作用。設施栽培者行浸苗處理時尤須恪遵上述技巧。

浸苗處理是重要關鍵技術，處理得宜，可大幅減

少後續栽培期間的蟲害問題。或有蟲害發生，透過監測，在蟲害的立足初期，即進行適時的治療。

治療時，友善植保資材的應用技術與策略研擬三個重要依據，包括防治資材的特性、防治對象的生態與習性及監測。前二者，即是所謂的知己知彼，一般都深知箇中道理，惟有監測，容易因為疏忽或認知差異而延誤防治時機。即時監測得蟲害的發生種類與數量，是調整防治策略的依據，包括調整防治方法、資材、強度與頻度。友善耕作的蟲害監測，有別於傳統取樣方式，非常重要。方法是每次取樣時必須將田區完全巡視，從中選取 5 個樣點 (面積不拘)。以目測認為被害嚴重或可疑者為取樣目標，視植株大小每個樣點取 5 株或枝條或葉片。如此，通常會比傳統逢機取樣的方式高估蟲害嚴重度，也因此才能因應分布不均勻、增殖又快速的害蟲，及早發現其立足初期，是族群即將爆發的前兆，若仍未發現該害蟲天敵的蹤跡，就應該適時調整防治策略，進入治療階段加以壓制。此為友善耕作中蟲害管理的防治門檻 (control threshold 或 action threshold)，較之慣行管理嚴格許多，但至為重要。

植物油混方特性，對小體形的蟲害，如蚜蟲、害蟎等的致死機制，可能與礦物油的堵塞呼吸系統 (Stadler & Buteler 2009) 類似，但未驗證，然施用時須覆蓋到蟲體。無論預防或治療，均須於下午三時以後，日照較弱時進行，避免造成藥害。

治療策略

1. 蚜蟲、害蟎

蚜蟲族群繁衍快速，例如棉蚜，自出生至可產後代所需發育時間，以在洋香瓜上為例，25°C 與 30°C 分別為 6.5 日與 5.2 日 (余與陳 2011)。田間實際溫度，尤其設施內更高，繁衍更加快速。棉蚜又是孤雌產雌胎生，再藉由共生螞蟻的搬運以及有翅型的飛行遷移，若再加上防治時的漏網之魚，則族群密度與分布範圍，在短時間內就可急遽上升。因此，當監測得葉片上有子代蚜出現時，即進入治療階段。以噴佈植物油混方治療時，200 倍水稀釋液對若蚜致死率雖幾可達 100%，但對成蚜僅約 9 成致死，故策略上應每週噴施 2 次，掌握處理時間間隔不長於上述發育所需時間，直至完全清除方能收效，必要時須持續至採收完畢。

植物油混方以噴佈方式治療二點葉蟎、神澤氏葉蟎、多食細蟎(*Polyphagotarsonemus latus* (Banks)) 等常見害蟎，對卵幾乎無致死作用 (未發表資料)，而且此類害蟎生活史短、繁殖力也強 (何與羅 1979；張國安 2000；何 1991)，故應參照防治棉蚜的方式。監測到有蟎產卵時，即視為蟎族群已經立足，必須進入治療階段。

2. 銀葉粉蝨

銀葉粉蝨隨時都可能入侵園區，於作物定植後即應放置黃色黏紙，進行監測 (Pinto-Zevallos & Vänninen 2013)。放置位置以植株嫩梢附近為主，須包括設施出入口附近植株，數量不拘。若監測有成蟲出現時，即視為進入治療階段。可噴佈植物油混方 500 倍水稀釋液，只要處理到成蟲即有 100%的致死率，但對卵與若蟲，即使提高濃度亦無理想之殺傷力 (未發表資料)。若監測到粉蝨成蟲密度高時，須改成高頻度的噴施，每周三次以上，可快速降低銀葉粉蝨成蟲密度，但須先通過 200 倍水稀釋液的藥害測試。若下位葉有發現粉蝨卵或若蟲，應斟酌疏除下位葉，並將之移離園區。

3. 薊馬

薊馬易受驚擾，浸漬或噴施植物油混方時，或有精油成分的忌避，可暫時驅離，但不易覆蓋蟲體。又因薊馬行動快捷，具強的爬行、跳躍能力，成蟲更能飛翔。因此治療時，施用植物油混方應配合懸掛黃色黏紙 (廖與廖 2002)，產生推拉 (push-pull) 效果 (Cook *et al.* 2007)。另外，常見的薊馬種類中，多有掉落或爬行至土表或落葉下化蛹的習性 (王 2002；

王與徐 2007)，所以再於土面鋪放苦楝粕 (Verghese & Giraddi 2005; Giraddi & Verghese 2007; Moorthy et al. 2014)，約400–600 kg/ha的用量，三管齊下。黏蟲紙可用黏蟲膠取代，其目的在防治，放置位置須於嫩梢附近，並隨植株長高而移動放置位置；依監測得的薊馬密度而訂定放置數量，不排除每公尺放1–2個。

在蟲害管理系統的預防與治療階段，植物油混方雖然都可以有角色扮演，但並非不可取代，舉凡植物油、礦物油等的都有類似的效果。防治策略之擬定，除參酌製劑的特性與限制，防除對象的生態、習性等知己知彼外，亦應廣納其他有效資材，多管齊下更能收效。防治資材推出時，其應用策略應該同時跟上，是研發者無可旁貸的義務。或許推出時不甚完備，後面可繼續充實。

結語

作物的生長狀態會影響病蟲害的發生與發展，栽培過程中看似無關病蟲害管理的作業，例如作物選種、選地、整地、灌溉、土壤與肥培管理、雜草管理、行株距、整枝、疏枝葉果、產期調節等，其實都會直接或間接地關係到病蟲害。所以，害物整合管理 (IPM) 其實應該將作物栽培措施視為害物管理的環節。那麼，作物害物整合管理 (ICPM, Integrated crop and pest management)，將更能體現害物管理的細節，把對害物的專注力，擴展到作物的發展需求，甚至耕地、環境等的長期視野。

農作生產使用友善植保資材，除了食安、人安的考量之外，如果也認同可兼顧生態，可以在農作產能無虞之下，適度、逐漸地朝有機農法努力。天敵保育是其應用方式之一，運用於農作物生產操作，可兼顧蟲害防治與生態保護，利用設置天敵保育特區 (余 2019)，或綠籬植物，草生栽培、間作等方式 (曾等 2017)。期許天敵與害蟲發生的高同步性，進而貢獻防治效果，且可與呈現生態的議題，如生物多樣性、綠色保育等相互結合，並行不悖。這期間可運用友善耕作的 ICPM 來消弭害物所造成的損失，確保生產。而且生態永續是我們的共同目標，友善農業是整個永續拼圖中值得努力的一塊，需要士農工商各領域的鼓勵與積極參與。

參考文獻

王清玲。2002。台灣薊馬生態與種類。纓翅目、錐尾亞目。農業試驗所特刊 第 99 號，328 頁。行政院農業委員會農業試驗所。

王清玲、徐孟愉。2007。農園植物重要薊馬。農業試驗所特刊 第 131 號，155 頁。行政院農業委員會農業試驗所。

余志儒。2009。乳化大豆油對棉蚜(同翅目：常蚜科)之致死效果。台灣農業研究 58: 265-272。

余志儒。2019。生物防治的理想-天敵保育。農業世界 426: 16-21。

余志儒、陳炳輝。2009。三種植物油對二點葉蟎之致死效果。台灣農業研究 58: 136-145。

余志儒、陳炳輝。2011。棉蚜在不同溫度下取食甜瓜之族群介量。台灣農業研究 60: 1-10。

余志儒、許北辰。2016。種苗浸漬乳化棕櫚油對神澤氏葉蟎的防除效果。台灣農業研究 65: 439-443。

余志儒、許北辰。2017。預防勝於治療：害蟲防治從害蟲侵入設施的 5 個主要途徑的防堵做起。農業試驗所技術服務 110: 26-30。

余志儒、許北辰。2019。植物油混方防治蟲害策略之研擬。235-248 頁，於：環境友善之植醫保健祕籍，黃振文等 編著，495 頁。五南圖書出版股份有限公司，台灣台北市。

何琦琛。1991。茶細蟎在檸檬、茶及辣椒上之生活史。中華農業研究 40: 439-444。

何琦琛、羅幹成。1979。 溫度對二點葉蟎 *Tetranychus urticae* 生活史及繁殖力之影響。中華農業研究 28: 261-271。

張國安。2000。 神澤葉蟎（*Tetranychus kanzawai* Kishida）在四種茶樹品種上之生活史、內在增殖率及田間族群消長。國立中興大學昆蟲學系碩士論文。台中。

曾竫萌、劉興榮、黃安葳。2017。 生態農業的綠色天地。行政院農業委員會花蓮區農業改良場特刊第155號，94頁。

廖信昌、廖蔚章。2002。 顏色黏板、塑膠布及氣味化合物配合植物萃取物對茄園南黃薊馬之防治效果。高雄區農業改良場研究彙報 13: 1-12。

Acharya, A., S. P. Moulik, S. K. Sanyal, B. K. Mishra, and P. M. Puri. 2002. Physicochemical investigations of microemulsification of coconut oil and water using polyoxyethylene 2-cetyl ether (Brij 52) and isopropanol or ethanol. J. Colloid Interface Sci. 245: 163-170.

Adhvaryu, A., S. Z. Erhan, and J. M. Perez. 2004. Tribological studies of thermally and chemically modified vegetable oils for use as environmentally friendly lubricants. Wear 257: 359-367.

Aguila, M. B., A. R. Pinheiro, J. C. F. Aquino, A. P. Gomes, and C. A. Mandarim-de-Lacerda. 2005. Different edible oil beneficial effects (canola oil, fish oil, palm oil, olive oil, and soybean oil) on spontaneously hypertensive rat glomerular enlargement and glomeruli number. Prostaglandins & other Lipid Mediators 76: 74-85.

Ahmad, K., C. C. Ho, W. K. Fong, and D. Tohi. 1996. Properties of palm oil-in-water emulsions stabilized by nonionic emulsifiers. J. Colloid Interface Sci. 181: 1595-604.

Aslan, İ., H. Özbek, Ö. Çalmaşur, and F. Şahin. 2004. Toxicity of essential oil vapours to two greenhouse pests, *Tetranychus urticae* Koch and *Bemisia tabaci* Genn. Indust. Crops Prod. 19: 67-173.

Assareh, M. H., K. Jaimand, and M. B.Rezaee. 2007. Chemical composition of the essential oils of six *Eucalyptus* species (Myrtaceae) from south west of Iran. J. Essent. Oil Res. 19: 8-10.

Attia, S., G. Lognay, S. Heuskin, and T. Hance. 2016. Insecticidal activity of *Lavandula angustifolia* Mill against the pea aphid *Acyrthosiphon pisum.* J. Entomol. Zool. Stud. 4: 118-122.

Bhatti, H. N., Z. Iqbal, S. A. S. Chatha, and I. H. Bukhari. 2007. Variations in oil potential and chemical composition of *Eucalyptus crebra* among different districts of Punjab–Pakistan. Int. J. Agri. Biol. 9: 136-138.

Butler, G. D., JR. D. l. Coudriet, and T. J. Henneberry. 1988. Toxicity and repellency of soybean and cottonseed oils to the sweetpotato whitefly and the cotton aphid in greenhouse studies. Southwest. Enlomol.13: 81-86.

Butler,G. D., and T. J. Jr. Henneberry. 1990. Pest control on vegetable and cotton with household cooking oils and liquid detergents. Southwestern Entomologist 15: 123-131.

Chang, Y. Y. 2007. Treatment of trichloroethylene in aqueous solution using nanoscale

zero-valent iron emulsion. Master thesis, Institute of Environmental Engineering, Sun Yat-Sen Univ. 161 pp.

Choi, W., S. G. Lee, H. M. Park, and Y. J. Ahn. 2004. Toxicity of plant essential oils to *Tetranychus urticae* (Acari: Tetranyidae) and *Phytoseiulus persimilis* (Acari: Phytoseiidae). J. Econ. Entomol. 97: 553-558.

Cook, S. M., Z. R. Khan, and J. A. Pickett. 2007. The use of push-pull strategies in integrated pest management. Ann. Rev. Entomol. 52: 375-400.

Dellacassa, E., P. Menéndez, P. Moyna, and E. Soler. 1990. Chemical composition of *Eucalyptus* essential oils grown in Uruguay. Flav. Frag. J. 5: 91-95.

Esmaeily, M., A. Bandani, I. Zibaee, I. Sharifian, and S. Zare. 2017. Sublethal effects of *Artemisia annua* L. and *Rosmarinus officinalis* L. essential oils on life table parameters of *Tetranychus urticae* (Acari: Tetranychidae). Persian J. Acarol. 6: 39–52.

Fenigstein, A., M. Eliyahu, S. Gan-mor, and D. Veierov. 2001. Effects of five vegetable oils on the sweetpotato whitefly *Bemisia tabaci*. Phytoparasitica 29: 197-206.

George, D. R., D. Masic, O. A. E. Sparagano, and J. H. Guy. 2009. Variation in chemical composition and acaricidal activity against *Dermanyssus gallinae* of four eucalyptus essential oils. Exp. Appl. Acarol. 48: 43-50.

Giraddi, R. S., and T. S. Verghese. 2007. Effect of different levels of neem cake, vermicompost and green manure on sucking pests of chilli. Pest Manage. Horticul. Ecosys, 13: 108-114.

Griffin, W. C. 1949. Classification of surface-active agents by HLB. J. Soc. Cosmet. Chem. 1: 311-326.

Hall, J. S., and G. E. Harman. 1991. Efficacy of oil treatments of legume seeds for control of Aspergillus and Zabrotes. Crop Prot. 10: 315-319.

Hori, M., and H. Komatsu. 1997. Repellency of rosemary oil and its components against the onion aphid, *Neotoxoptera formosana* (Takahashi) (Homoptera, Aphididae). Appl. Entomol. Zool. 32: 303-310.

Kassimi, A., L. El Watik, and M. Moumni. 2012. Study of the insecticidal effect of Oregano and Thyme essential oils and Neem carrier oil on the alfalfa aphid. J. Environ. Sol. 1: 1-5.

Mareggiani, G., S. Russo, and M. Rocca. 2008. *Eucalyptus globulus* (Mirtaceae) essential oil: efficacy against *Aphis gossypii* (Hemiptea: Aphididae), an agricultural pest. Rev. Latinoam. Quím. 36: 16-21.

Miller, R. L. 1983. Spray oil insecticides effectively control some insect and mites. Am. Nurseryman 158: 37-43.

Miresmailli, S., and M. B. Isman. 2006. Efficacy and persistence of rosemary oil as an acaricide against twospotted spider mite (Acari: Tetranychidae) on greenhouse tomato. J. Econ Entomol. 99: 2015-2023.

Mishra, D., A. K. Shukla, A. K. Dubey, and A. K. Dixit. 2006. Insecticidal activity of vegetable oils against mustard aphid, *Lipaphis erysimi* Kalt., under field condition. J. Oleo Sci. 55: 227-231.

Moawad, S. S., A. Sharaby, I. M. Ebadah, and H.

El-Behery. 2015. Efficiency of zinc sulfate and some volatile oils on some insect pests of the tomato crop. Glo. Adv. Res. J. Agri. Sci. 4: 182-187.

Mohamed, A. I., A. S. Hussein, S. J. Bhathena, and Y. S. Hafez. 2002. The effect of dietary menhaden, olive, and coconut oil fed with three levels of vitamin E on plasma and liver lipids and plasma fatty acid composition in rats. J. Nutr. Biochem. 13: 435-441.

Moorthy, P. N. K., S. Saroja, H. R. Ranganath, K. Shivaramu, and K. A. Paripoorna. 2014. Controlled release formulation of oiled neem cake for insect pest management. Pest Manage Horticul. Ecosys. 20: 133-136.

Obeng-Ofori, C. H. Reichmuth, J. Bekele, and A. Hassanali. 1997. Biological activity of 1,8 cineole, a major component of essential oil of *Ocimum kenyense* (Ayobangira) against stored product beetles. J. Appl. Entomol. 121: 237-243.

Picard, I., R. G. Hollingsworth, S. Salmieri, and M. Lacroix. 2012. Repellency of essential oils to *Frankliniella occidentalis* (Thysanoptera: Thripidae) as affected by type of oil and polymer release. J Econ Entomol. 105: 1238-47.

Pinto-Zevallos, D. M., and I. Vänninen. 2013. Yellow sticky traps for decision-making in whitefly management: What has been achieved? Crop prot. 47: 74-84.

Rashid, U., F. Anwar, B. R. Moser, and G. Knothe. 2008. Moringa oleifera oil: a possible source of biodiesel. Bioresour. Technol. 99: 8175-8179.

Ravasio, N., F. Zaccheria, M. Gargano, S. Recchia, A. Fusi, N. Poli, and R. Psaro. 2002. Environmental friendly lubricants through selective hydrogenation of rapeseed oil over supported copper calalysts. Appl. Catal. A: General 233: 1-6.

Schuster, D. J., S. Thompson, L. D. Ortega, and J. E. Polston. 2009. Laboratory evaluation of products to reduce settling of sweetpotato whitefly adults. J. Econ. Entomol. 102: 1482-1489.

Sefidkon, F., M. H. Assareh, Z. Abravesh, and M. M. Barazandeh. 2007. Chemical composition of the essential oils of four cultivated *Eucalyptus* species in Iran as medicinal plants. Iranian J. Pharmaceutical Res. 6: 135-140.

Stadler, T., and M. Buteler. 2009. Modes of entry of petroleum distilled spray-oils into insects: a review. Bull. Insectolo. 62: 169-177.

Szelag, H., and W. Zwierzykowski. 1999. The behaviour of modified monoacylglycerol emulsifiers in emulsion systems. Colloids Surf. A: Physicochemical and Engineering Aspects 155: 349-357.

Verghese, T. S., and R. S. Giraddi. 2005. Integration of neem cake in plant protection schedule for thrips and mite management in chilli (Cv. Byadagi). Karnataka J. Agricul. Sci. 18: 154-156.

Yaghmura, A., A. Aserina, Y. Mizrahib, A. Nerdb, and N. Gartia. 1999. Argan Oil-In-Water Emulsions: Preparation and Stabilization. JAOCS 76: 15-18.

表 1. 六種植物油對棉蚜、神澤葉蟎、二點葉蟎之防治率

Table 1. The control rate of 6 plant oil for *Aphis gossypii*, *Tetranychus kanzawai*, *T. urticae*

Plant oil [z]	No. pest before treated	Control rate after treated (%)		
		1 day	3 days	7 days
			Aphis gossypii	
Ricinus communis	30.8 ± 9.5	20.5 ± 5.9c [y]	56.6 ± 8.5a	45.1 ± 10.4ab
Chrysanthemum sp.	31.3 ± 5.9	10.3 ± 8.9cd	42.3 ± 29.1a	36.4 ± 9.7b
Vitellaria paradoxa	32.5 ± 4.7	16.5 ± 14.2d	40.3 ± 15.8a	35.9 ± 6.1b
Cottonseed oil	41.8 ± 9.4	34.8 ± 4.1b	49.1 ± 10.2a	44.5 ± 20.5ab
Flaxseed oil	40.8 ± 5.4	46.2 ± 2.8a	54.4 ± 11.9a	57.0 ± 16.2a
Palm oil	49.8 ± 10.7	44.8 ± 16.2a	52.4 ± 5.6a	66.3 ± 11.6a
Water (control)	35.3 ± 8.4			
			Tetranychus kanzawai	
Ricinus communis	10.0 ± 0	44.4 ± 9.6b	88.9 ± 19.2a	87.9 ± 15.7a
Chrysanthemum sp.	10.0 ± 0	76.7 ± 25.2a	87.8 ± 10.7a	95.7 ± 7.5a
Vitellaria paradoxa	10.0 ± 0	51.1 ± 25.2ab	56.3 ± 23.3b	49.3 ± 11.4b
Cottonseed oil	10.0 ± 0	51.1 ± 18.4ab	57.4 ± 8.5b	58.1 ± 17.9b
Flaxseed oil	10.0 ± 0	62.2 ± 39.8ab	68.9 ± 45.5ab	74.7 ± 33.8ab
Palm oil	10.0 ± 0	51.1 ± 33.7ab	66.7 ± 28.9ab	68.9 ± 31.5ab
Water (control)	10.0 ± 0			
			Tetranychus urticae	
Ricinus communis	10.0 ± 0	80.0 ± 20.0a	88.9 ± 19.2a	70.8 ± 50.5b
Chrysanthemum sp.	10.0 ± 0	69.2 ± 25.5ab	77.5 ± 9.8a	77.2 ± 20.9b
Vitellaria paradoxa	10.0 ± 0	65.0 ± 21.8ab	59.4 ± 16.9b	80.0 ± 22.0b
Cottonseed oil	10.0 ± 0	78.3 ± 20.2a	86.7 ± 23.1a	100.0 ± 0 a
Flaxseed oil	10.0 ± 0	52.5 ± 13.0b	50.2 ± 14.6b	60.3 ± 8.1c
Palm oil	10.0 ± 0	54.2 ± 12.3b	54.9 ± 19.5b	70.3 ± 14.3b
Water (control)	10.0 ± 0			

[z] : Oil and Tween 80 are mixed at 9 : 1 (V/V), then diluted with water 200 times to be tested.

[y] : Data on control rates were corrected by Abbott’s formula and showed by $\bar{x}$ (sd), and means within a column followed by the same letter are not significantly different by LSD test at 5% level.

.

表 2、三種乳化植物油不同濃度處理二點葉蟎後經 24 與 72 小時之防治率 [z]

Table 2. The control rates of 3 emulsified plant oils against *Tetranychus urticae* after 24 and 72 hours from treaed

Oil	Concentration of oil (mL/L) [y]					Linear regression
	20	10	5	2.5	1.25	
24 h after treatment						
Coconut	93.7a [x]	66.3b	35.4b	40.9a	6.2b	y = 4.06x+17.00
	(5.2)	(10.2)	(4.6)	(11.7)	(0.2)	R^2 = 0.88
Palm	96.3a	94.1a	57.1a	17.7b	16.4a	y = 4.45x+21.83
	(2.3)	(2.3)	(4.9)	(8.8)	(6.8)	R^2 = 0.75
Rapeseed	79.7b	48.1c	28.2c	20.5b	10.7ab	y = 3.57x+9.79
	(4.4)	(6.4)	(1.0)	(7.1)	(3.0)	R^2 = 0.99
72 h after treatment						
Coconut	100.0a	81.8b	63.8a	57.1a	21.8a	y = 3.40x+38.52
	(0.0)	(14.7)	(13.2)	(21.0)	(1.7)	R^2 = 0.79
Palm	100.0a	100.0a	67.1a	39.3a	25.7a	y = 3.84x+36.57
	(0.0)	(0.0)	(4.2)	(17.0)	(11.2)	R^2 = 0.74
Rapeseed	97.3a	78.9b	47.3b	39.1a	19.8a	y = 3.89x+26.4
	(3.2)	(7.2)	(1.9)	(11.1)	(5.4)	R^2 = 0.90

[z] : Data quoted from 余與陳 2009.

[y] :Vegetable oil emulsified with surfactant in 1:1 (V/V), and concentrations showed as oils only.

[x] : Data on control rates were corrected by Abbott’s formula and showed by $\bar{x}$ (sd), and means within a column followed by the same letter are not significantly different by LSD test at 5% level.

表 3. 三種乳化植物油處理二點葉蟎後經 24 與 72 小時之 LC_{50} 與 LC_{90} [z]

Table 3. The LC_{50} and LC_{90} of three emulsified plant oils to *Tetranychus urticae* after 24 and 72 hours from treaed

Oil [y]	LC_{50} (mL/L, limits [x])	LC_{90} (mL/L, limits)
	24 h post-treatment	
Coconut	5.13 (3.72-6.96)	19.38 (12.82-40.96)
Palm	4.08 (2.35-7.00)	11.85 (6.93-51.94)
Rapeseed	8.74 (6.24-14.09)	58.68 (27.50-203.62)
	72 h post-treatment	
Coconut	2.23 (1.22-3.22)	10.62 (6.92-24.90)
Palm	2.59 (1.31-4.21)	7.53 (4.53-40.46)
Rapeseed	3.66 (2.67-4.92)	17.82 (11.41-39.29)

[z,] : Footnote is the same as table 2.

[y] : Plant oils emulsified with surfactant in 1:1 (V/V), LC_{50} and LC_{90} are the concentrations of oils.

[x] : The lower and upper concentrations at 95% confidence limits.

表 4. 三種 HLB 值介面活性劑不同濃度處理後 24 與 72 小時對二點葉蟎之防治率 [z]

Table 4. The control rates of 3 HLB value surfucant in different concentratios against *Tetranychus urticae* after 24 and 72 hours from treaed

Surfactant [y]	Concentration of surfactant (mL/L)					Linear regression
	20	10	5	2.5	1.25	
24 h after treatment						
5.3	83.1a [x]	61.6a	13.6a	13.6a	9.1a	y = 4.38x + 1.18
	(1.5)	(5.6)	(4.0)	(4.0)	(7.4)	R^2 = 0.91
10.8	60.7a	40.6b	11.4a	11.4a	3.9a	y = 3.06x + 2.19
	(20.0)	(6.3)	(8.9)	(8.9)	(5.3)	R^2 = 0.95
6.7	63.9a	47.6ab	23.7a	23.7a	5.3a	y = 3.15x + 5.84
	(14.2)	(16.0)	(11.3)	(11.3)	(5.7)	R^2 = 0.93
72 h after treatment						
5.3	95.9a	74.4a	22.3a	14.7a	12.6a	y = 4.83x + 6.55
	(2.7)	(15.3)	(4.3)	(14.7)	(10.4)	R^2 = 0.91
10.8	74.8b	56.2a	39.8a	15.0a	17.1a	y = 3.20x + 15.80
	(11.0)	(4.9)	(10.1)	(10.1)	(5.2)	R^2 = 0.91
6.7	89.4a	74.1a	38.0a	25.3a	9.3a	y = 4.15x + 15.10
	(9.4)	(13.0)	(16.0)	(11.7)	(9.7)	R^2 = 0.89

[z, x] : Footnote is the same as table 2.

[y] : Surfactant was represented by HLB-value.

表 5. 三種植物油混合不同比例介面活性劑處理後 24 與 72 小時對二點葉蟎之防治率 [z]

Table 5. The control rate of 3 plant oils emulsified with different ratio to surfucant against *Tetranychus urticae* after 24 and 72 hours from treaed

Ratio of surfactant to oil	Coconut oil (2.23 mL/L) [y]		Palm oil (2.59 mL/L)		Rapeseed oil (3.66 mL/L)	
(V/V)	24 h	72 h	24 h	72 h	24 h	72 h
2:1	37.3a [x]	62.6a	40.9a	57.1a	37.5a	51.0a
	(11.5)	(18.6)	(13.0)	(12.5)	(8.9)	(18.8)
1:1	37.2ab	53.4ab	21.6b	41.1ab	25.0ab	46.9a
	(9.3)	(9.3)	(5.8)	(13.1)	(8.9)	(13.5)
0.5:1	22.7b	46.2ab	24.9b	39.4b	20.2b	45.8a
	(9.2)	(12.2)	(8.7)	(7.4)	(9.8)	(22.3)
0.25:1	25.2ab	42.8b	26.2b	39.9b	23.8ab	35.7a
	(9.7)	(7.1)	(5.3)	(12.6)	(12.4)	(10.5)
0.125:1	24.7ab	38.7b	25.1b	33.4b	22.9b	33.1a
	(8.3)	(13.3)	(11.5)	(9.7)	(4.3)	(10.2)

[z, x] : Footnote is the same as table 2.

[y] : It was the LC_{50} of oil against *T. urticae* at 72 h post-treatment.

表 6. 大豆油乳化液對棉蚜的防治率 [z]

Table 6. The control rate of soybean oil against *Aphis gossypii*

Concentration of oil (mL/L) [y]	Mean of aphid treated (range)	Control rates (%) of aphid at time after treatment 1 d	3 d	7 d
5	28.8 (20-38)	85.6 ± 3.3 aB [x]	92.7 ± 2.0 aA	95.2 ± 2.0 aA
2.5	29.3 (21-41)	80.2 ± 3.5 aA	84.3 ± 5.9 bA	84.2 ± 7.7 bA
1.25	37.3 (23-46)	41.2 ± 9.6 bA	42.5 ± 8.8 cA	39.3 ± 9.2 cA
0.625	30.0 (20-40)	19.4 ± 3.1 cA	20.2 ± 3.8 dA	15.8 ± 4.8 dA
0.3125	37.8 (28-52)	13.2 ± 3.6 cA	13.2 ± 3.6 dA	10.9 ± 5.9 dA
0 (control)	24.0 (23-25)			

[z] : Data quated from 余 2009.

[y] : Emulsified soybean oil was prepared by mixing with emulsifier at 1:1 (V/V) ratio, and tested at five concentrations of oil.

[x] : Data on control rates were corrected by Abbott's formula and showed by mean ± sd; means within a column and a row followed by the same letter with lower and upper case, respectively, are not significantly different by Fisher's LSD test at 5% level.

表 7. 大豆油致死棉蚜之 LC_{50} 與 LC_{90} [z]

Table 7. The LC_{50} and LC_{90} of emulsified soybean oils to *Aphis gossypii*

Time after treatment (day)	LC_{50} (mL/L)	LC_{90}
1	1.28 (0.98-1.68) [y]	5.78 (3.80-11.69)
3	1.14 (0.90-1.45)	4.15 (2.94-7.16)
7	1.09 (0.86-1.38)	3.96 (2.81-6.82)

[z] : Footnote is the same as table 6.

[y] : LC_{50} and LC_{90} were expressed as the concentrations of oil. Data in brackets were lower and upper concentrations at 95% confidence limits.

表 8. 乳化劑對棉蚜的防治率 [z]

Table 8. The control rate of surficant against *Aphis gossypii*

Concentration (mL/L)	Mean of aphid treated (range)	Control rate (%) of aphid at time after treatment 1 d	3 d	7 d
5	18.0 (15-22)	48.9 ± 8.7 aA [y]	52.3 ± 6.3 aA	52.3 ± 6.3 aA
2.5	19.3 (15-27)	30.3 ± 1.1 bA	31.9 ± 3.8 bA	31.9 ± 3.8 bA
1.25	20.7 (17-26)	17.7 ± 5.4 cA	22.1 ± 5.8 cA	22.1 ± 5.8 cA
0.625	18.7 (16-21)	17.9 ± 3.2 cA	19.0 ± 2.1 cA	19.0 ± 2.1 cA
0.3125	23.0 (20-26)	15.4 ± 5.0 cA	15.4 ± 5.0 cA	15.4 ± 5.0 cA
0 (control)	17.7 (16-20)			

[z] : Footnote is the same as table 6.

[y] : Data on control rates were corrected by Abbott’s formula and showed by mean ± sd; means within a column and a row followed by the same letter with lower and upper case, respectively, are not significantly different by Fisher’s LSD test at 5% level.

表 9. 乳化劑與大豆油不同混合比例對棉蚜的防治率 z

Table 9. The control rate of *Aphis gossypii* treated with surficant mixed soybean oil in different ratio

Ratio of emulsifier to soybean oil y	Mean of aphid treated (range))	Control rate (%) of aphid at time after treatment		
		1 d	3 d	7 d
2:1	21.5 (19-25)	64.7 ± 5.3 a x	65.5 ± 5.0 a	65.5 ± 5.0 a
1:1	22.0 (21-24)	52.2 ± 2.1 b	55.3 ± 5.6 ab	58.8 ± 4.3 a
0.5:1	17.8 (17-20)	52.2 ± 5.0 b	53.0 ± 4.1 ab	57.2 ± 6.9 ab
0.25:1	18.0 (17-19)	58.6 ± 14.5 ab	58.1 ± 14.5 a	58.1 ± 14.5 ab
0.125:1	18.0 (16-20)	40.1 ± 4.9 b	43.3 ± 9.6 b	45.0 ± 8.9 b
Water (control)	18.5 (16-21)			

z : Footnote is the same as table 6.

y : The concentration of soybean oil was 1.09 mL/L (Value of LC_{50} of oil against *A. gossypii* at 7 day post-treatment.) in all mixture.

x : Data on control rates were corrected by Abbott' s formula and showed by mean ± sd; means within a column followed by the same letter are not significantly different by LSD test at 5% level.

表 10. 四種大豆油對棉蚜的防治率 z

Table 10. The control rate of *Aphis gossypii* treated with 4 kind of soybean oil

Oil source y	Mean of aphid treated (range)	Control rate (%) of aphid at time after treatment		
		1 d	3 d	7 d
Sigma	30.5 (17-52)	67.0 ± 3.5ab x	91.2 ± 7.7ab	93.0 ± 8.0ab
Great Union	42.0 (30-64)	78.4 ± 9.9a	89.8 ± 7.7ab	95.3 ± 4.0a
Taiwan Sugar	30.8 (20-38)	62.9 ± 10.5b	93.8 ± 4.6a	93.8 ± 4.6ab
Taisun	42.0 (15-36)	78.4 ± 6.8a	83.9 ± 4.7b	86.0 ± 4.9b
Water (control)	29.0 (15-41)			

z : Footnote is the same as table 6.

y : The oil source is Sigma-Aldrich Co., Great Union Trading Co., Ltd., Taiwan Sugar Corporation, and Taisun Enterprise Co., Ltd., respectively, in order from top. And their concentrations were equal to the LC_{90} on 7 day post-treatment of Sigma-Aldrich with a ratio of emulsifier to soybean oil was 0.25 to 1.

x: Footnote is the same as table 9.

表 11. 四種植物精油對棉蚜、神澤葉蟎、二點葉蟎之防治率

Table 11. The control rate of 4 essential oils against *Aphis gossypii, Tetranychus kanzawai, T. urticae*

Botanic EO [z]	No. mite before treated	Control rate after treated (%)		
		1 day	3 days	7 days
	Aphis gossypii			
丁香(*Eugenia caryophyll*)	19.0 ± 10.0 [y]	29.4 ± 37.4	27.0 ± 46.8	26.4 ± 45.8
肉桂(*Cinnamomum cassia*)	24.7 ± 17.6	0	0	8.0 ± 13.9
茴香(*Foeniculum vulgre*)	36.3 ± 16.3	37.4 ± 36.1	33.3 ± 57.7	25.8 ± 44.6
艾葉(*Artemisiae argyi*)	19.0 ± 2.0	5.0 ± 8.7	3.6 ± 6.3	33.3 ± 57.7
水 Water (control)	17.0 ± 13.0			
	Tetranychus kanzawai			
丁香(*Eugenia caryophyll*)	24.0 ± 9.6	1.9 ± 3.3	3.9 ± 3.3	6.3 ± 8.8
肉桂(*Cinnamomum cassia*)	33.0 ± 10.1	0	2.5 ± 2.4	0
茴香(*Foeniculum vulgre*)	23.0 ± 1.0	1.5 ± 2.6	4.4 ± 4.3	26.6 ± 37.6
艾葉(*Artemisiae argyi*)	18.0 ± 7.0	4.4 ± 7.7	4.4 ± 4.7	4.2 ± 5.9
水 Water (control)	22.3 ± 3.1			
	Tetranychus urticae			
丁香(*Eugenia caryophyll*)	34.7 ± 2.1	2.5 ± 2.3	31.3 ± 51.7b [z]	0
肉桂(*Cinnamomum cassia*)	31.3 ± 9.1	5.5 ± 4.8	75.9 ± 28.2a	37.0 ± 52.3a
茴香(*Foeniculum vulgre*)	42.7 ± 17.5	6.5 ± 9.1	63.8 ± 55.3ab	31.6 ± 54.7a
艾葉(*Artemisiae argyi*)	56.3 ± 1.2	3.2 ± 3.1	28.1 ± 39.9b	23.3 ± 40.5a
水 Water (control)	50.3 ± 30.4			

[z] : Each essential oil was blended with Tween 80 at a 9:1 (V/V) ratio, and then tested with a 4000-fold water dilution.

[y] : Data on control rates were corrected by Abbott’s formula and showed by mean ± sd; means within a column followed by the same letter are not significantly different by LSD test at 5% level.

表 12. 四種尤加利精油的組成份 (%)

Table 12. The component (%) of essential oils derived from 4 *Eucalyptus* sp.

Component	*E. globulus*	*E. radiata*	*E. dives*	*E. citriodora*
1.8-Cineole	82.0	68.0	56.0	0.6
α-pinene	3.6	4.2	1.1	2.4
β-pinene	0.8	3.8		0.5
Limonene	2.1		7.1	
γ-terpinene	0.7		4.9	
p-cymene	0.9			
Terpineol-4	0.9			
α-terpineol	2.5	9.5	5.2	
Aldehydes (varies type)		7.1		
other alcohols		6.5		
α-terpinene			1.2	
cis-β-terpineol			0.7	
menthone			2.0	
terpinenel-4-ol			4.5	
iso-menthone			0.8	
menthol			3.5	
γ-terpineol			1.5	
geraniol			3.5	
neral			0.6	
geranial			0.6	
caryophyllene			0.1	
Citronellal				86.0
Iso pulegol				2.2
Citronellol				4.2
Citronellyl acetate				1.1
beta caryophyllene				0.3

Data offered by FPI Sales Ltd. UK.

表 13、四種尤加利精油對棉蚜棉蚜、神澤葉蟎、二點葉蟎之防治率與致死效果

Table 13. The control and lethal efficacy of 4 *Eucalyptus* EOs against *Aphis gossypii, Tetranychus kanzawai, T. urticae*

	Mortality (%) after treated			Control rate (%) after treated		
Essential oil [z]	1 day	3 days	7 days	1 day	3 days	7 days
	Aphis gossypii					
Eucalyptus glogblus	15.7ab [y]	19.9a	35.7a	5.3a	4.3a	3.7a
E. radiata	15.1ab	36.6a	51.8a	12.4a	13.2a	11.7a
E. dives	24.4a	39.1a	27.4a	6.5a	13.4a	10.7a
E. citriodora	9.2b	40.0a	64.7a	7.0a	11.6a	10.1a
	Tetranychus kanzawai					
Eucalyptus glogblus	15.2a	20.6a	– [x]	14.1a	25.2a	26.6a
E. radiata	14.2a	4.0b	–	9.2a	18.2a	24.8a
E. dives	10.6a	2.7b	–	6.6a	7.4b	11.0a
E. citriodora	6.6a	2.4b	–	4.4a	7.7b	17.5a
	Tetranychus urticae					
Eucalyptus globulus	38.5a	0.5a	–	22.3ab	23.7a	26.9a
E. radiata	13.6b	17.7a	–	10.5c	15.7a	14.9a
E. dives	40.6a	7.4a	–	25.4a	29.2a	32.1a
E. citriodora	28.7ab	15.5a	–	14.8bc	13.0a	19.1a

[z]: Each essential oil was blended with surficant at a 1:1 (V/V) ratio, and tested with a water dilution of 0.5 mL/L essential oil.

[x]: Data on mortalities ad control rates were corrected by Abbott's formula and showed by mean; means within a column followed by the same letter are not significantly different by LSD test at 5% level.

[x]: There was no mite found on the wilting host plant.

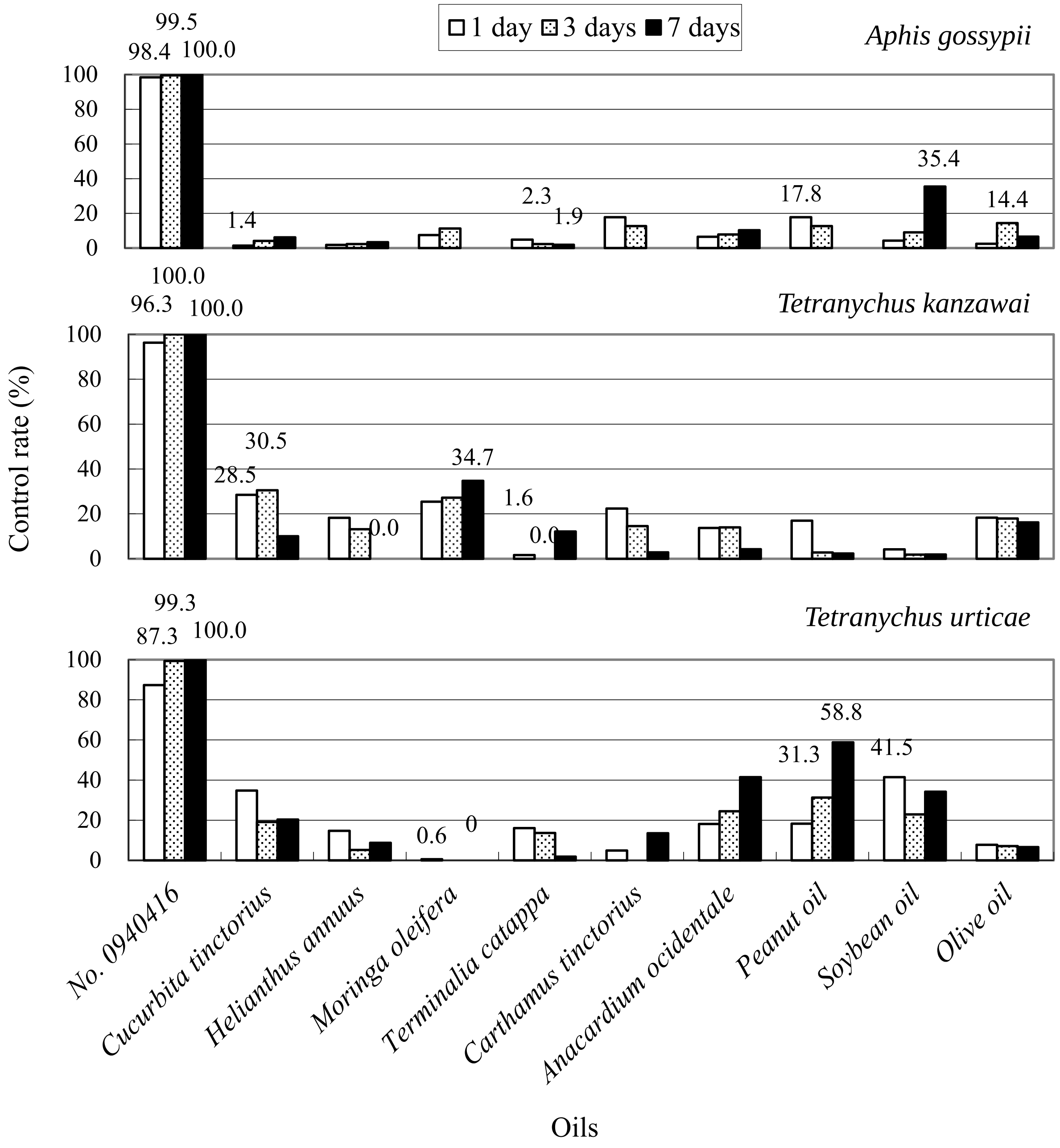

圖 1. 十種植物油水稀釋 500 倍對棉蚜、神澤葉蟎、二點葉蟎之防治率。試材皆與 Tween 80 以 9：1 混合乳化後受測。

Fig. 1. The control rate of 4 botanic EOs against *Aphis gossypii, Tetranychus kanzawai, T. urticae*. Materials emulsified with Tween 80 in 9:1 (V/V).

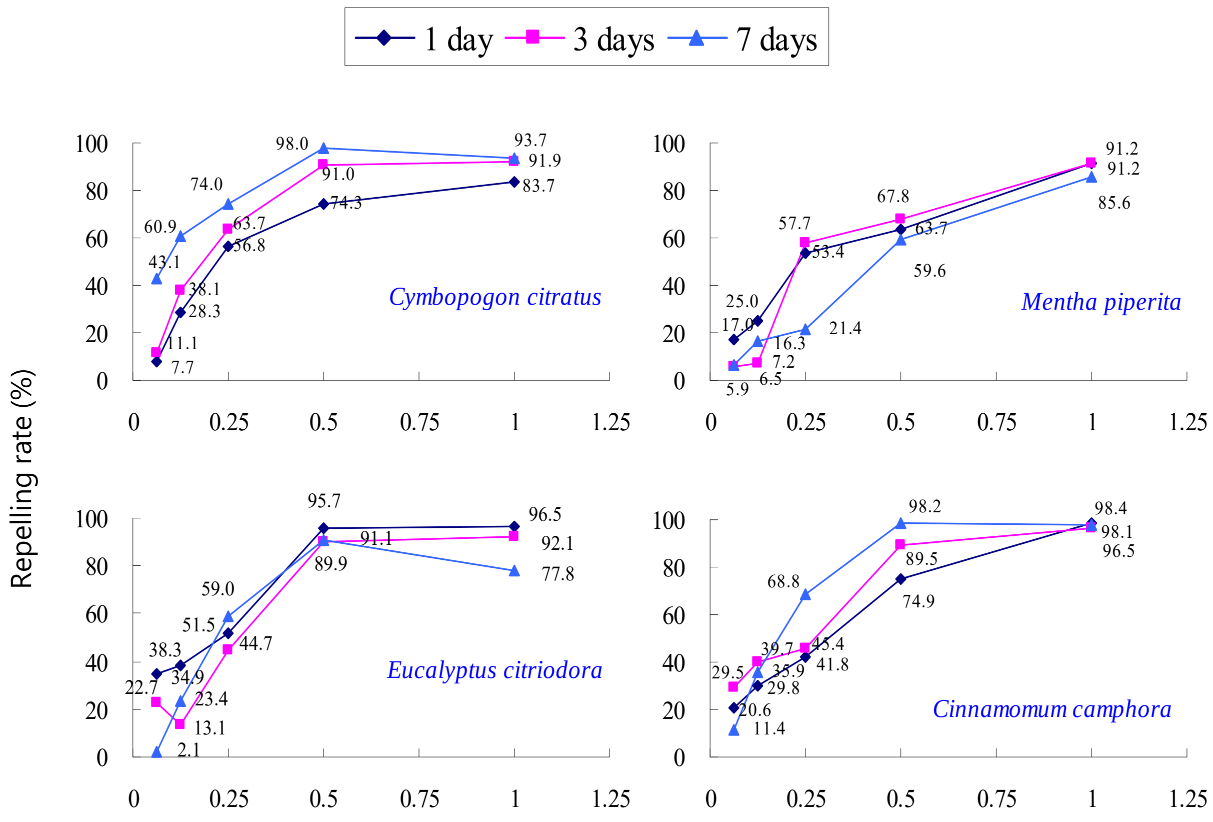

圖 2. 四種植物精油對棉蚜之忌避效果。

Fig. 2. The repelling efficacy of 4 essential oils against *Aphis gossypii*.

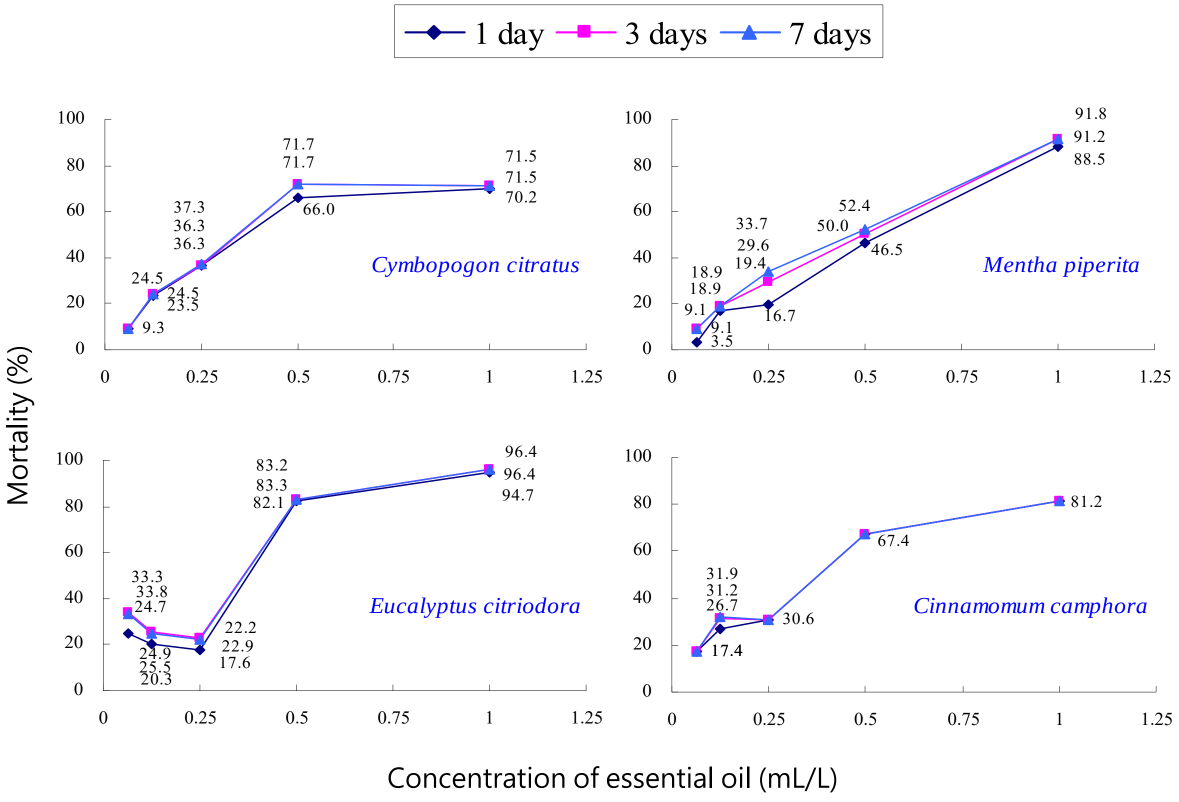

圖3. 四種植物精油對棉蚜之致死效果。

Fig. 3. The lethal efficacy of 4 essential oils against *Aphis gossypii*

The R&D and application of Plant Oils Mixture

Jih-Zu Yu [1]*, Yaw-Jen Dong [2], Pei-Chen Hsu [2], and Wan-Hsiu Yang [2]

[1] Associate Reseach Fellow, Applied Zoology Division, TARI, Wufeng, Taichung, Taiwan, ROC.

[2] Assistant Reseach Fellow, Applied Zoology Division, TARI, Wufeng, Taichung, Taiwan, ROC.

Abstrct

The lethal efficacy of 23 plant species seed oils and 11 plant essential oils against cotton aphis (*Aphis gossypii* Glover), spider mites Kanzawa (*Tetranychus kanzawai* Kishida), and two-sptted spider mites (*T. urticae* Koch) were preliminarily screened. Then, we further try to compare the control efficacy of 3 plant oils with differnt saturated fatty acid content, coconut oil, palm oil and rapeseed oil (94.1, 51.9 and 5.1%, respectively) against *Tetranychus urtice*. Results showed that the LC_{50} of such 3 oils were 2.23, 2.59, and 3.36 mL/L at 72 h after treated, and the LC_{90} were 10.62, 7.53, and 17.82 mL/L, respectively. It is suggested that the lethal effect may be related to the content of saturated fatty acids. Coconut oil and palm oil will be developed potentially. In addition, compare the control efficacy of 4 different brands of soybean oil against *A. gossypii*. Three famous brands (Tatong Enterprise Co., Ltd., Taiwan Sugar Company, Taishan Enterprise Co., Ltd.) and Sigma -R&D grade of Aldrich Co. included. When the surfactant is mixed with each brand oil at 0.25:1 (V/V), the aphid control effects were good, and there were not significant difference among the four brands. Soybean oil is also to be developed potentialiy. And the ratio of surfactants mixed with above potential oils at 0.25:1 (V/V) is considable. Based on above results, "Plant Oil Mixture" was prepared consequently. The Plant Oils Mixture can be used for prevention and treatment in the pest management system. In prevention stage, Plant Oils Mixture can be used for soaking seedlings before planting, and sprayed weekly after planting that by using its essential oil content to play a deterrent effect. According to the field monitoring results, pest management should enter the treatment stage that the application dosage and frequency of Plant Oils Mixtur must be strengthen if the pest populations reach control threhold. In the formulation of pest management strategies, the characteristics and limitations of the plant protect materials, and the ecology, habits, etc. of control targets shoule be considered. However, other effective materials should be widely recruied to make up for the possible shortcoming of individual combat if the control ability of the Plant Oils Mixtur is insufficient.

Key words: Plant Oils Mixture, seedling soaked treatment, pest management strategy.

*Correspondence address
e-mail: zyu@tari.gov.tw